Image Transmission System for Two-Way Television *

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A two-way television system, in combination with a telephone circuit, has been developed and demonstrated. With this system two people can both see and talk to each other. It consists in principle of two television systems of the sort described before the June, 1927, Convention of the American Institute of Electrical Engineers. Scanning is by the beam method, using discs containing 72 holes, in place of 50 as heretofore. Blue light, to which the photoelectric cells are quite sensitive, is used for scanning, with a resultant minimizing of glare to the eyes. Water-cooled neon lamps are employed to give an image bright enough to be seen without interference from the scanning beam. A frequency band of 40,000 cycles width is required for each of the two television circuits. Synchronization is effected by transmission of a 1275 cycle alternating current controlling special synchronous motors rotating 18 times per second. Speech transmission is by microphone and loud speaker concealed in the television booth so that no telephone instrument interferes with the view of the face.

DURING the past few years, since the physical possibility of television has been established, the chief problems which have received attention have been those of one-way transmission. In particular, the experimental work in radio television has had for its principal goal the broadcasting of television images, which is inherently transmission in one direction. At the time of the initial demonstration of television at Bell Telephone Laboratories in 1927,[1] one part of the demonstration consisted of the transmission to New York of the image of a speaker in Washington simultaneously with the carrying on of a two-way telephone conversation. At that time it was stated that two-way television as a complete adjunct to a two-way telephone conversation was a later possibility. It is the purpose of this paper to describe a two-way television system now set up and in operation between the main offices of the American Telephone and Telegraph Company at 195 Broadway and the Bell Telephone Laboratories at 463 West Street, New York. It consists in principle of two complete television transmitting and receiving sets of the sort used in the 1927 one-way television demonstration. In realizing this duplication of apparatus, however, a number of characteristic special problems arise, and the paper deals chiefly with matters peculiar to two-way as contrasted with one-way television.

* Presented at June, 1930, meeting of A.I.E.E., Toronto, Canada.

[1] *Bell System Technical Journal*, October, 1927, pp. 551–652.

Physical Arrangement and Operation

The detailed description of the optical and electrical elements of the two-way television system will be more readily grasped if it is preceded by an account of the general arrangement of the parts and of the method of operation of the system from the standpoint of the user.

The physical arrangement of the two-way television system is shown by the pictorial sketch Fig. 1, and in the photographs Fig. 2 and Fig. 3. The terminal apparatus is largely concentrated into a booth,—the television booth—similar in many respects to the familiar telephone booth, and a pair of cabinets, which contain the scanning discs and light sources. As in the 1927 demonstration, scanning is performed by the beam method, the scanning beam being derived from an arc lamp whose light passes through a disc furnished with a spiral of holes and thence through a lens on the level of the eyes of the person being scanned. The light reflected from the person's face is picked up by a group of photoelectric cells for subsequent amplification and transmission to the distant point. The signals received from the distant point are translated into an image by means of a neon glow lamp directly behind a second disc driven by a second motor placed below the first and inclined at a slight angle to it. The two discs, which are shown in the center cabinet of Fig. 2, are of slightly different sizes; the upper one 21″ in diameter and the lower one 30″. They differ from the discs used in the earlier demonstration in that in place of the 50 spirally arranged holes formerly used, they carry 72 holes whereby the amount of image detail is doubled. While with the earlier "50 line" picture recognizable images of a face were obtainable, the aim in this new development was to reproduce the face so clearly that there would never be any doubt of recognizability, and so that individual traits and expressions would be unmistakably transmitted. This doubled number of image elements necessarily requires, for the same image repetition frequency (18 per second) twice the transmission band, or approximately 40,000 cycles as against 20,000 for the 1927 image.

The only part of the television apparatus visible to the user is the array of photoelectric cells which are in the television booth behind plates of diffusing glass. In addition to the photoelectric cells and their immediately associated amplifiers, the booth contains a concealed microphone and loud speaker. By means of these, the voice is transmitted to the distant station and received therefrom without the interposition of any visible telephone instrument which could obscure the face.

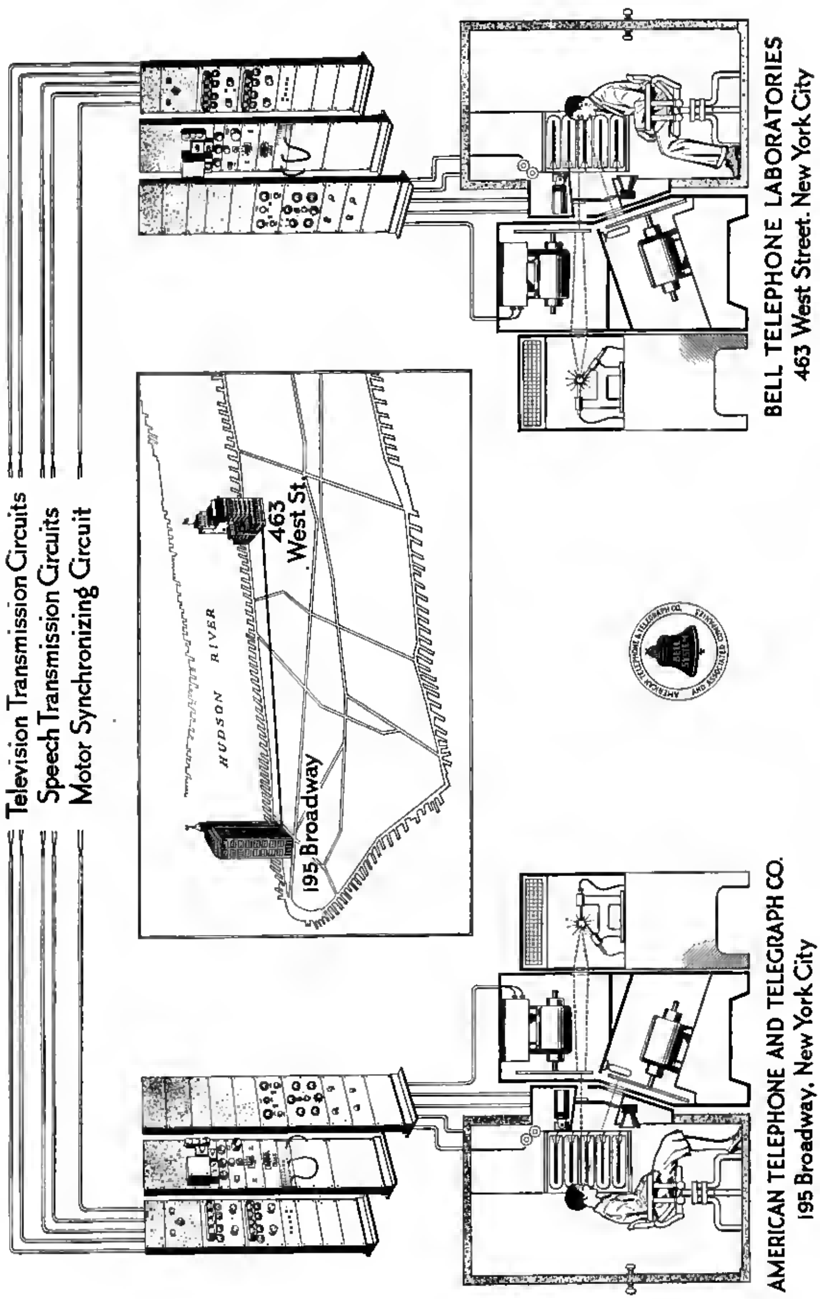

Fig. 1—Pictorial sketch of two-way television system.

From the standpoint of the user, the operation of the combined television and telephone system is reduced to great simplicity. He enters the booth, closes the door, seats himself in a revolving chair, swings around to face a frame through which the scanning beam reaches his face, and upon seeeing the distant person, he talks in a natural tone of voice, and hears the image speak. Conversation is carried on as though across a table.

Fig. 2—The three major cabinets of the television-telephone apparatus.

Optical Problems

Some of the more special of the problems encountered in two-way television are primarily optical in character. The principal one is that of regulating the intensity of the scanning light and of the image which is viewed so that the eye is not annoyed by the scanning beam or the neon lamp image rendered difficult of observation. It has been necessary for the solution of this problem to reduce the visible intensity of the scanning beam considerably below the value formerly used and to considerably increase the brightness of the neon lamp.

The means adopted consists first, in the use of a scanning light of a color to which the eye is relatively insensitive but to which photoelectric cells can be made highly sensitive. For this purpose blue light has been used, obtained by interposing a blue filter in the

path of the arc light beam, and potassium photoelectric cells specially sensitized to blue light and more sensitive than those previously used have been developed. The number of these cells and their area has also been increased over those used in the earlier television apparatus so that the necessary intensity of the scanning beam is decreased.

The second half of the problem, namely that of securing a maximum intensity of the neon lamp, has been attained by the development of water-cooled lamps capable of carrying a high current. The net result of the use of the blue light for scanning, of more sensitive photoelectric cells, and of the high efficiency neon lamps is that the user of the apparatus is subjected only to a relatively mild blue

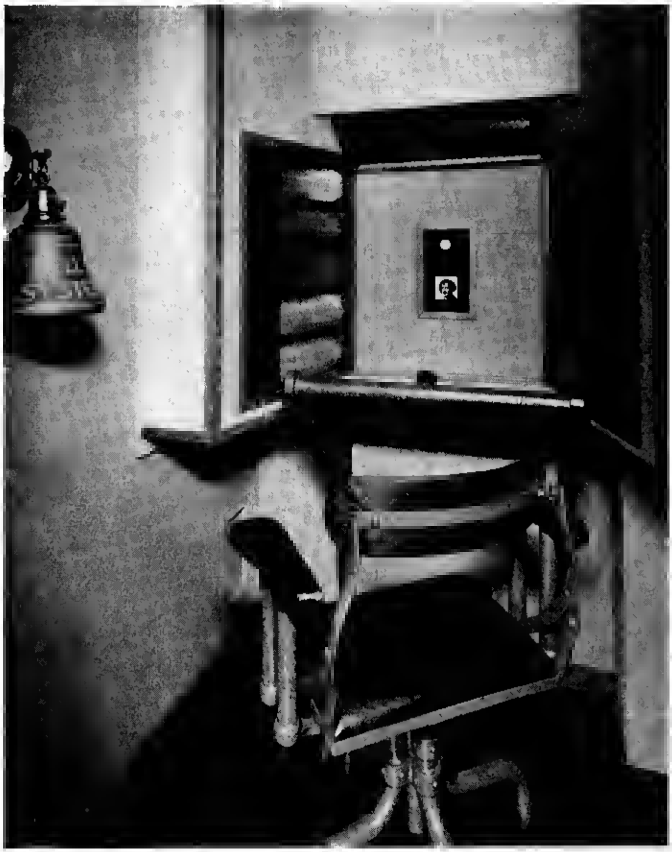

Fig. 3—Interior of the television booth.

light sweeping across his face, which he perceives merely as a blue spot of light lying above the incoming image. Figure 3 shows the interior of the television booth with the frame through which the observer sees the image of the distant person.

A second optical problem is the arrangement of the photoelectric cells required in order to obtain proper virtual illumination of the observer's face. As we have previously pointed out in discussing the beam scanning method,[2] the photoelectric cells act as virtual light sources and may be manipulated both as to their size and position like the lights used by a portrait photographer in illuminating the face. In the present case, it is desired to have the whole face illuminated and accordingly photoelectric cells are provided to either side and above. One practical difficulty which is encountered is that eyeglasses, which often cause annoying reflections in photography are similarly operative here. For this reason, it is important that the photoelectric cells be placed as far to either side or above as possible. The banks of photoelectric cells shown in Fig. 3 are accordingly much farther removed from the axis of the booth than were the three cells used in the first demonstration. In the position which has been chosen for the cells, reflections from eyeglasses are not annoying unless the user turns his face considerably to one side or the other.

The number of cells has been so chosen as to secure a good balance of effective illumination from the three sides and it has been found desirable to partly cover the cells on one side in order to aid in the modelling of the face by the production of slight shadows in one direction.

Another optical problem is the illumination of the interior of the booth. There must, of course, be sufficient illumination for the user to locate himself, and it is also desirable that the incoming image and the scanning spot be not seen against an absolutely black background. The illumination of the booth is by orange light, to which the cells are practically insensitive, and so arranged that the walls and floor are well illuminated. In addition to the wall and floor illumination, a small light is provided on the shelf bar in front of the observer so as to cast orange light on the front wall surrounding the viewing frame. This light contributes materially to reducing the glaring effect of the scanning beam, and to the easy visibility of the incoming image.

In addition to the optical features which are visible to the person sitting in the booth, there are very necessary optical elements which

[2] *Jnl. Optical Soc. of America,* March, 1928, p. 177.

have to do with the positioning of the outgoing and incoming images. A practical problem which is encountered when customers of various heights use the apparatus is that the scanning beam, if fixed in its position, would strike too high or too low upon many faces. In order to direct the beam up or down as is required, a variable angle prism, consisting of two prisms arranged to rotate in opposite directions,

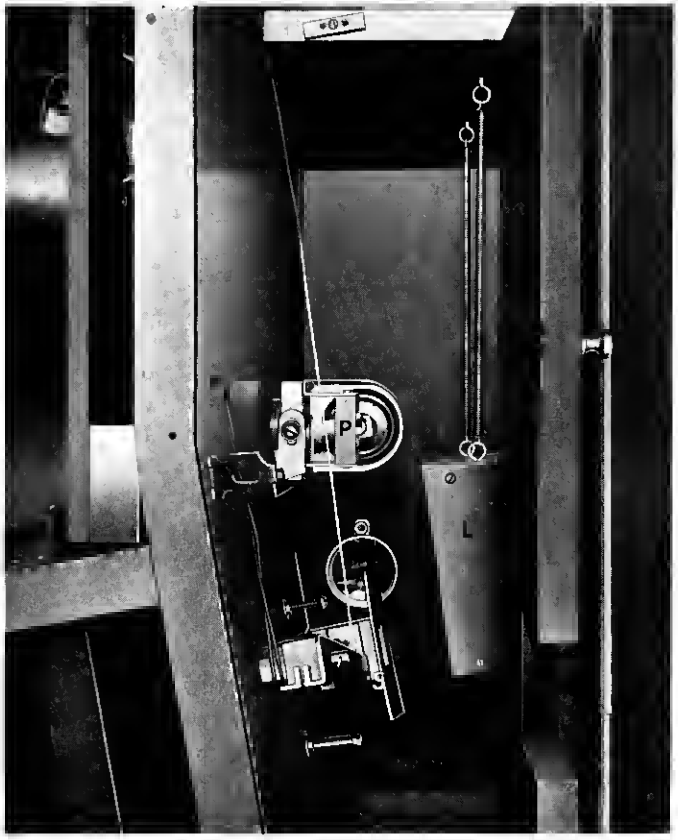

Fig. 4—Optical means for controlling heights of scanning and viewing beams.

is interposed in the path of the scanning beam. This prism, which lies directly in front of the projection lens used with the upper disc, is shown in Fig. 4 at *P*. Its rotation is controlled by a knob with a numbered dial. The exact position is determined by the operator by reference to a monitoring image which will be described below.

Another optical element which serves two purposes, is a large convex lens lying between the receiving disc and the observing frame,

shown at L, Fig. 4. This lens is used to magnify the incoming image to such a size that the image structure is just on the verge of visibility, under which condition the face of the distant person appears as though he were approximately eight feet away. In addition to acting as a magnifier, this lens serves to position the incoming image to fit the height of the user. For, by raising or lowering it by means of a knob, the operator, using the information as to the observer's height obtained from the position of the scanning beam, locates the lens so that the virtual image appears in the proper position.

Photoelectric Cells and Associated Circuits

The photoelectric cells used in this apparatus are similar in shape to those used in the first demonstration, but somewhat larger. Each

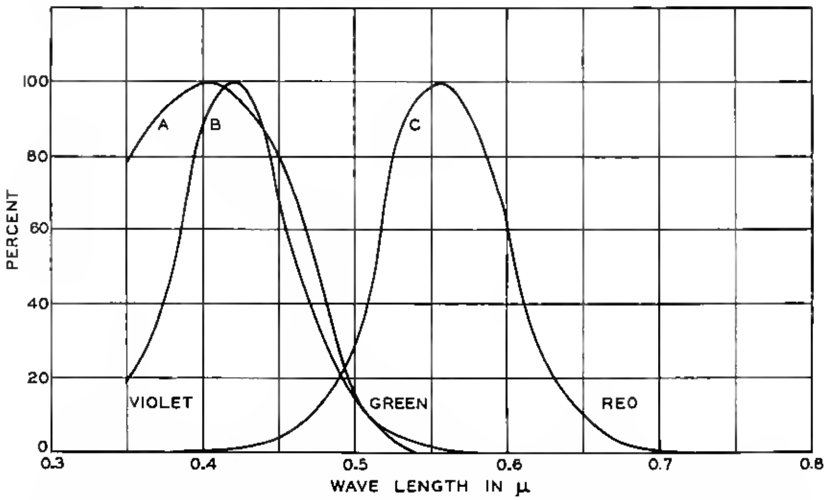

Fig. 5—*A*. Relative optical transmission of the blue filter through which the scanning beam passes. *B*. Relative sensitivity of the photoelectric cells to various parts of the spectrum. *C*. Relative sensitivity of the eye to various parts of the spectrum.

cell is twenty inches long and four inches in diameter, giving it an area of approximately eighty square inches for collecting light. The anode is made in the form of a hollow glass rod wound with wire. This construction prevents the electrical oscillations that would otherwise result from mechanical vibrations of the anode. The sensitive cathode consists of a coating, covering the rear wall of the tube, of potassium sensitized with sulphur.[3] This kind of cell is considerably more sensitive than the older type of potassium-hydride cell

[3] A. R. Olpin, *Phys. Rev.*, 33, 1081 (1929).

while still having most of the sensitiveness in the blue region of the spectrum. Figure 5 shows the response of the photoelectric cells used to the various parts of the spectrum together with the transmission of the blue filter and the brightness of the various parts of the spectrum as evaluated by the human eye. The very great efficiency of the photoelectric cells and the inefficiency of the eye to the light used are apparent.

To amplify the photoelectric current, the cells are filled with argon at a low pressure. Photoelectrons passing from the sensitive film to the anode ionize the gas atoms along their paths and thus cause a greater flow of current. The ionization of the gas does not, however, instantaneously follow sudden variations of the true photoelectric emission from the sensitive film, that is, there is a time lag in the

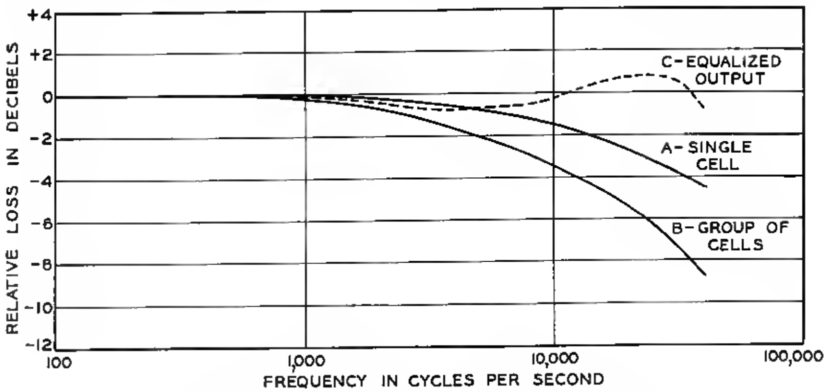

Fig. 6—Loss in response of photoelectric cells at high frequencies.

ionization of the gas and in the disappearance of ionization. This lag results in a relative loss and phase shift of the high frequency components of a television signal with respect to the low frequency components which become serious in the wider frequency range utilized in the 72 line image. The relative loss in output from a single large photoelectric cell at high frequencies is shown in decibles by curve A of Fig. 6.

In the television booth, the twelve large cells mounted in the walls of the booth present an area of approximately seven square feet to collect light reflected from a subject. To secure the desired effective illumination, the cells are mounted in three groups, comprising a group of five cells in each of the two side walls of the booth and a group of two cells in the sloping front wall above the subject. The twelve cells are enclosed in a large sheet copper box, provided with

doors to each group. The cells of each group are connected in parallel through the input resistance of a two stage resistance-capacity coupled amplifier similar to those previously used. This raises the level of the signal to such a point that the output of the three amplifiers may be carried through shielded leads and connected in parallel to a common amplifier.

The metal anodes and lead wires of the cells in parallel in any one group give an appreciable capacity to ground, which results in a further loss in amplitude and phase shift of the high frequency components of the signal. The combined loss introduced by ionization of the gas in the cells and by capacity to ground is shown by curve B of

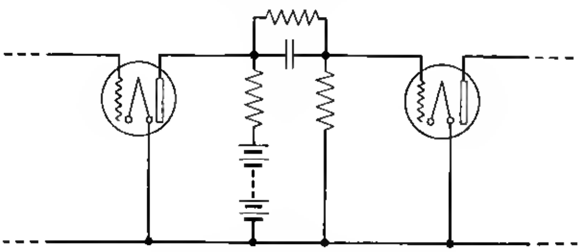

Fig. 7—Schematic of interstage amplifier coupling to equalize for the high frequency losses in the photoelectric cells.

Fig. 6. This combined loss is equalized by an interstage amplifier coupling, Fig. 7. The equalized output from the photoelectric cells is shown by curve C, Fig. 6.

Two-Way Image Signal Amplifiers

The vacuum tube system used to amplify the photoelectric cell currents in two-way television is patterned closely after that used previously in one-way television, and the description here will be confined chiefly to novel features. These new features are necessary to take care of the doubled frequency band which results when the scanning is done with a 72-hole disc rather than with a 50-hole one, and to provide sufficient power to operate the high intensity neon lamp which is essential to two-way television. Certain other new features have been introduced in order to simplify the apparatus and to reduce the maintenance required to keep it in good working condition.

The vacuum tubes which operate at low energy levels are the so-called "peanut" type, chosen because of their freedom from microphonic action and their low interelectrode capacities. Protection against mechanical and acoustical interference is secured by mounting these tubes in balsa wood cylinders which are loaded with lead rings

and cushioned in sponge rubber. The tubes are electrically connected in cascade by means of resistance-capacity coupling, so that the whole amplifier system is stable over long periods of time and is also uniformly efficient over the required frequency band. Grid bias for the small tubes is supplied by the potential drop across a resistance in the filament circuit; the power requirements for the low level stages of the amplifier are filled by 6-volt filament batteries and 135-volt plate batteries, all located externally where they can be checked and replaced conveniently.

The amplifier system is divided into units of convenient size as shown in Fig. 8. Associated with each of the three banks of photo-

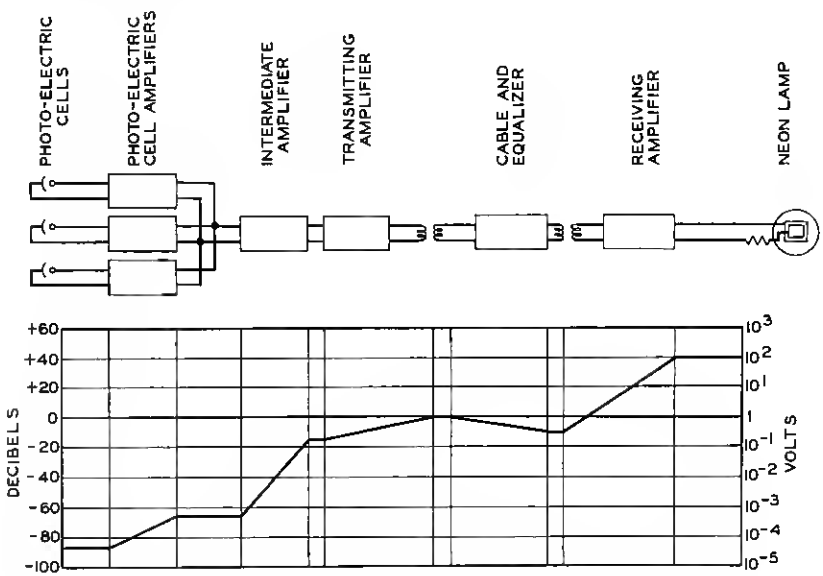

Fig. 8—Schematic diagram of the complete television channel and the relative voltage levels of the signal along the channel.

electric cells is a two-stage unit known as the photoelectric cell amplifier; the combined output of these three units is carried to a four-stage unit known as the intermediate amplifier whose output is of sufficiently high level to be carried outside the copper cell cabinet to the three-stage transmitting power amplifier on the relay rack. A four-stage unit known as the receiving power amplifier is also on the rack, and serves to amplify the signal from the other station to a level which will yield an image of satisfactory contrast when it is translated into a light variation by means of the neon lamp. The final stage of this amplifier consists of two special 250-watt tubes in

parallel. These large tubes are used because their plate impedance is of the same order of magnitude as the impedance of the neon lamp, and because they will supply the necessary direct current to the neon lamp without overheating.

Figure 8 also shows what may be termed a voltage level diagram for the whole system. Ordinates on this diagram represent voltage amplitudes at the junctions between units of the system, and by themselves tell nothing at all about the power conditions in the system, since the impedances are not specified. It is interesting to observe that the signal voltage produced by the three banks of photoelectric cells has an effective value of about 50 microvolts across the 50,000 ohm input resistance; the transmitting amplifier delivers about 1 volt to the 125-ohm cable circuit, and the receiving amplifier delivers about 100 volts to the 1,000 ohm neon lamp circuit. The signal current through the neon lamp has an effective value about a thousand million times greater than that of the current variation in one of the photoelectric cells.

The most outstanding contribution to the development of television amplifiers is the combination of output and input transformers whose transmission characteristics are shown in Fig. 9, *A*, and whose impedance characteristics are shown in Fig. 9, *B*, and *C*. The exceptionally wide frequency range, corresponding to a ratio of limiting frequencies of 5,000 to 1, transmitted by these transformers is due largely to the use of chrome permalloy, a recently developed core material having very high permeability. The improved characteristics are also the result of refinements in design which involve the use of adjusted capacities and resistances to control the characteristics at the higher frequencies. Due to the fact that each terminated transformer looks like a resistance of 125 ohms over practically the entire frequency range of the image signal, it makes no difference in the form of the overall voltage amplification characteristic of the circuit whether the transformers are connected together directly or by means of the equalized cable circuit whose characteristic in shown in Fig. 10. Advantage of this circumstance is taken in providing switching means whereby each transmitting amplifier may be connected through a resistance pad to its local receiving amplifier, enabling a person to see his own image in the television booth, which is a convenience in making apparatus adjustments.

Transformers of this type must be carefully protected against magnetizing forces which might cause polarization of the core material. In order to keep the plate current of the final tube of the transmitting power amplifier from flowing through the winding of the output

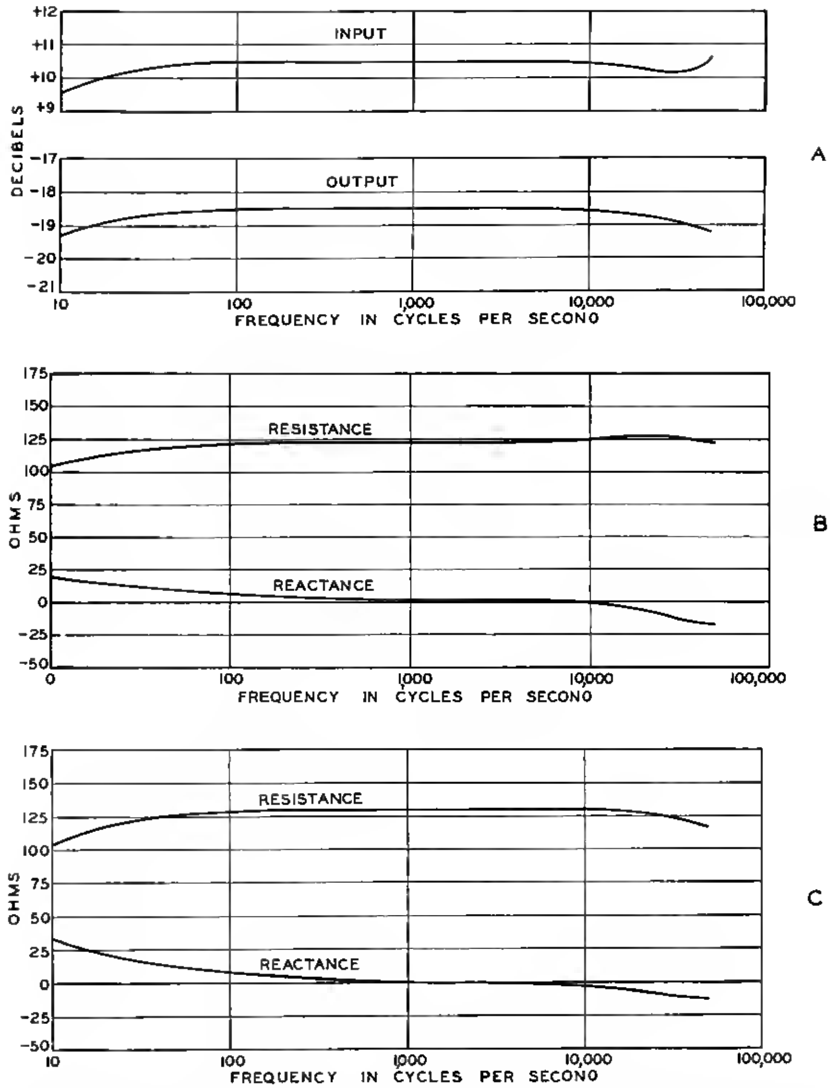

Fig. 9—*A*. Voltage ratio characteristics of W-7879 input transformer and W-7880 output transformers, each connected between its rated impedance. *B*. Impedance characteristic of W-7880 output transformer with 1765 ohm resistance load. *C*. Impedance characteristic of W-7879 input transformer with 20 mmf. capacity load.

transformer, the transformer winding is shunted by a battery and a resistance in series. The resistance is made high, so that the transmission loss due to bridging it across the circuit is small; the voltage of the battery is made equal to the potential drop across the resistance due to the plate current of the tube, so that the average voltage across both the battery and the resistance, and hence across the transformer winding, is zero.

A vacuum thermocouple is connected in series with the line winding of the output transformer, serving as level indicator for the transmitting amplifier. The level indicator for the receiving amplifier is

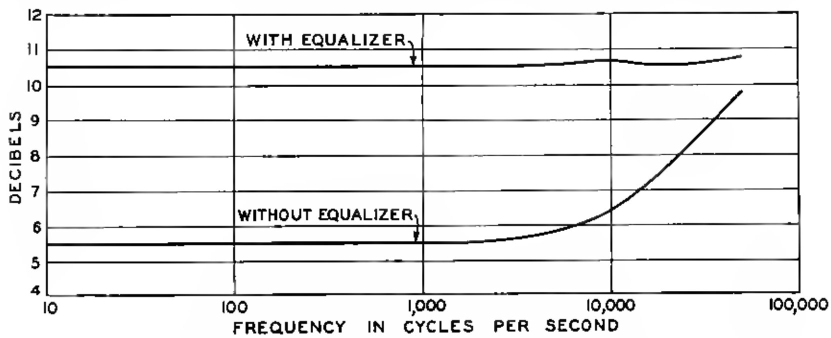

Fig. 10—Insertion loss characteristic of cable cricuits which transmit the image signal, measured between 125 ohm resistances.

a vacuum thermocouple in series with the grid resistance of the two 250-watt tubes.

The electrical control panels associated with one terminal of the television apparatus are shown in Fig. 11.

Transmission Circuits

Two special requirements for the two-way television transmission circuits are to be emphasized. The first, which has already been referred to, is the wide frequency transmission band, from 18 cycles to 40,000 cycles, which must have a high degree of uniformity of transmission efficiency and freedom from phase distortion. The second is the necessity for *two* circuits for the television images. This arises from the fact that the two parties to the conversation must both see and be seen at all times. There can be no interruption of one face by the other, comparable with the alternation of the role of speaker and listener in telephony which permits the use of a single circuit for ordinary speech communication.

The terminal stations of the two-way television system are con-

nected by eight underground circuits, each consisting of 13,032 feet of No. 19 gauge and 390 feet of No. 22 gauge non-loaded cable. Two circuits are used for transmitting the image signals, two for the accompanying speech, one for the synchronizing current, two are used as

Fig. 11—Control apparatus panels associated with one terminal of the television apparatus.

order wires, and one is kept as a spare. All of the circuits have identical transmission characteristics, but equalization is necessary only on the two which carry the image signals. Figure 10 shows the insertion loss characteristic of each circuit, and also shows the insertion loss charac-

teristic of the image circuits when the image line equalizers are included.

Although the distance between the stations is small the requirements of the television system from the standpoint of freedom from noise and other interference require that considerable care be given to the selection of the cable circuits used. All terminal connections are made through balanced repeating coils or transformers so that all of the circuits are balanced to ground. Also, in order to insure that the crosstalk between the various channels be unnoticeable the terminal equipment is so adjusted that approximately the same amount of power is transmitted by each circuit.

Neon Lamps and Associated Circuits

After amplification, the received television signal is impressed on the grids of two power tubes in parallel to furnish current for a neon receiving lamp. The terminal lamp circuit is shown in Fig. 12.

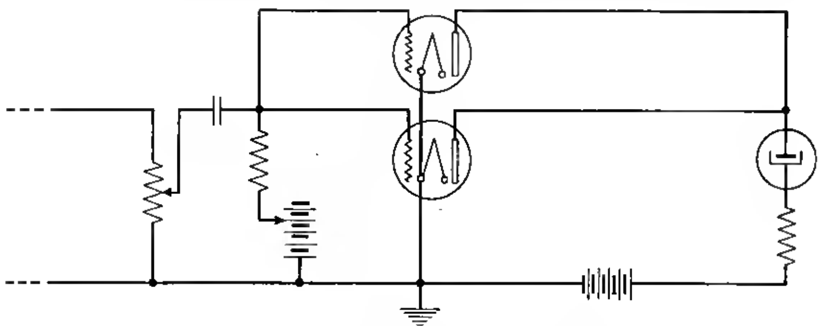

Fig. 12—Schematic of neon lamp circuit.

The grid bias of the two power tubes is varied by the operator to control the DC plate current, which replaces the original DC signal component suppressed at the sending end. The quality of the reproduced image is determined by the operator's control over the relative levels of the incoming AC signal and the restored DC current.

The television current from the power tubes is translated back into light by a water-cooled neon lamp designed to operate on a large current. The structural details of the lamp are shown in Fig. 13. Heavy metal bands attach the rectangular cathode to a hollow glass stem occupying the central portion of the tube. Water from a small circulating pump flows continuously through the glass stem and cools the cathode by thermal conduction through the metal bands. To reduce sputtering of the cathode and consequent blackening of the

glass walls, the front surface of the cathode is coated with beryllium. This metal resists the disintegrating action of the glow discharge very satisfactorily and gives the lamp a prolonged life. Other metal surfaces in the tube are shielded from the discharge by mica plates; and

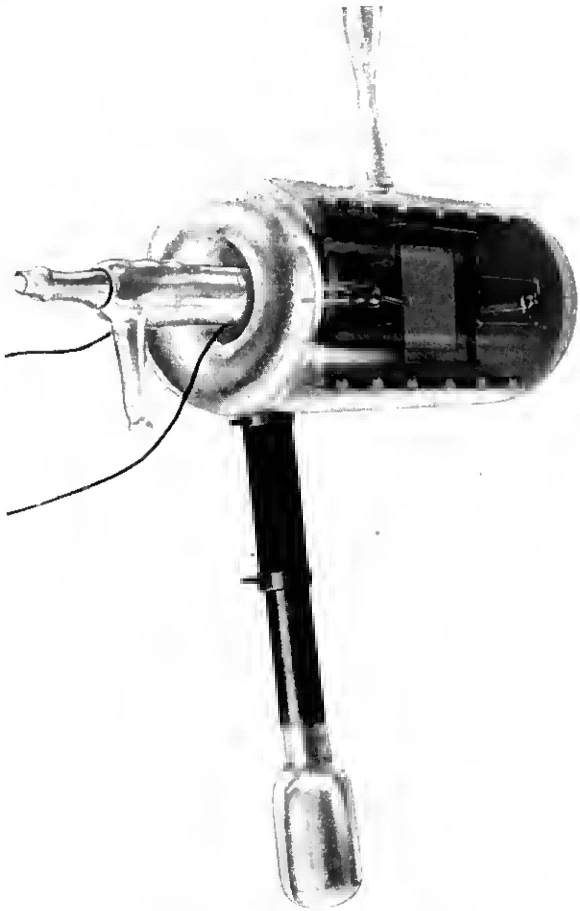

Fig. 13—Water-cooled neon lamp.

the discharge passes from the frame-like anode to the front surface of the cathode, covering it with a brilliant layer of uniform cathode glow.

Pure neon in a plate type of lamp gives a very inferior reproduction of an image. The impedance of the lamp is relatively high and comprises both a resistance and a reactance which vary with frequency. The variation in the impedance causes a relative loss in the frequency components of the signal and also introduces spurious phase shifts.

In addition, pure neon has an after-glow; the gas continues to glow for an appreciable time after current ceases to flow. This after-glow casts spurious bands of illumination out to one side of the brighter image details.

A small amount of hydrogen in the neon prevents such an afterglow; and at the same time improves the circuit characteristics of the lamp. The total impedance of the lamp is lower, making it a less influential part of the lamp circuit; and the resistance and reactance vary in such a manner that the phase shift is more nearly proportional to frequency (a phase shift proportional to frequency causes no distortion in the reproduction of an image). Other active gasses may be used with the neon to improve the operation of a television lamp, but one or two per cent of hydrogen is most satisfactory.

Since hydrogen is absorbed by the electrodes in a glow discharge, it slowly disappears from the neon during operation of the lamp. For this reason the lamp is provided with a small side reservoir of hydrogen. The lamp and the reservoir carry porous plugs immersed in a pool of mercury; and a flexible rubber connection permits the two plugs to be brought into contact at will. Minute quantities of hydrogen may be introduced into the lamp by simply bringing the two plugs into contact for a short time.

Even with this improvement the circuit characteristics of a lamp are not ideal. With power tubes it is usually desirable to include a fixed resistance in series with the lamp to prevent semi-arcing conditions. Such a resistance also makes the lamp a less influential fraction of the total circuit impedance.

Optical Monitoring System

In order to insure that the incoming and outgoing images are properly positioned, no matter what the stature of the person sitting in the booth, and that the images shall be of proper quality, it is essential to have some means for the operator to observe and adjust these images. The optical monitoring system provided consists of an outgoing monitor and means for adjusting the scanning beam, and an incoming monitor and means for adjusting the position of the viewing lens to suit the height of the sitter.

The outgoing monitoring system is the same as that used in the one-way television apparatus which has already been described. A small neon lamp (Fig. 14, at bottom of top disc) is placed behind the sending disc but displaced several frames from the aperture through which the arc lamp beam passes. By continuing the spiral of holes part way around it is possible to see the complete image from the auxiliary neon

lamp, to which the outgoing signals are also supplied. In order to see this monitoring lamp from the operator's position, a right-angle prism and a magnifying lens are placed in front of the disc and the image is observed through an opening in the side of the motor cabinet. The

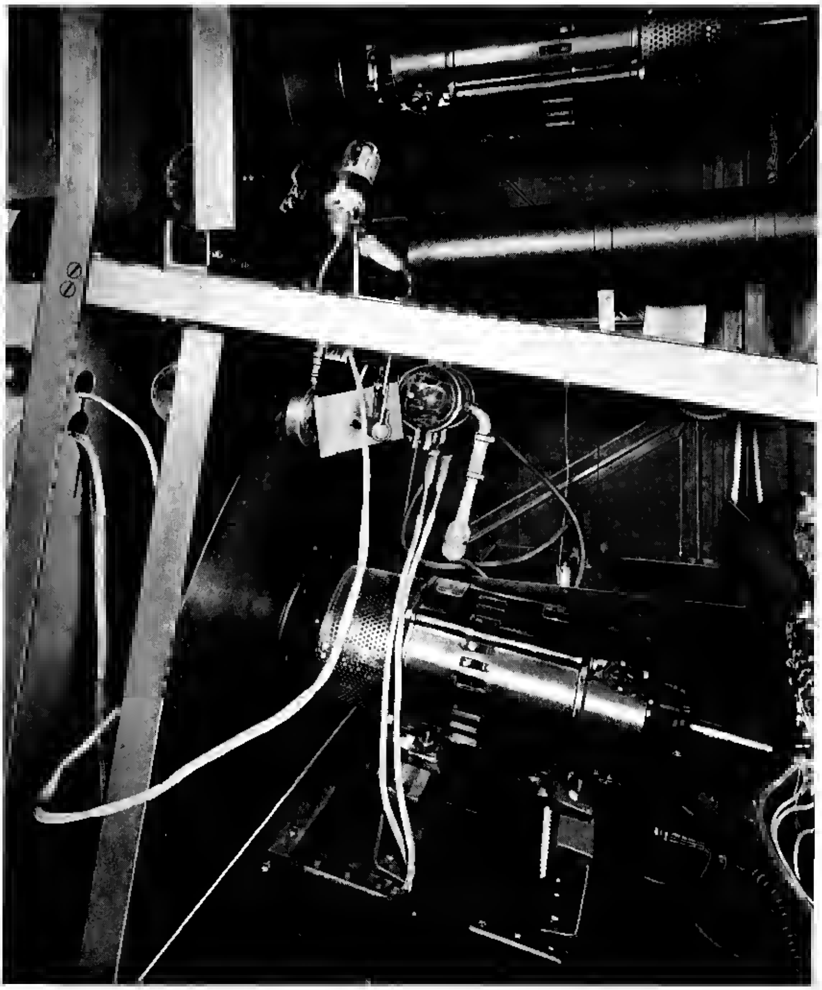

Fig. 14—Sending and receiving discs, with neon lamps and optical arrangements for image monitoring.

task of the operator is to direct the scanning beam up or down by means of the variable angle prism until the face of the person in the booth is centrally located. This adjustment is facilitated by a wire

which passes across the image and is placed at the height at which the user's eyes should appear.

The height of the observer's eyes is an indication of the position which should be taken by the large magnifying lens L, and the operator, after having properly placed the scanning beam, reads the scale on the variable angle prism dial, and then sets the magnifying lens by turning its controlling knob to the same number. When both adjustments are complete, the person in the booth will not only be properly scanned but will be in the best position to see the image.

In order to monitor the incoming image, an optical arrangement is adopted by means of which light from the water-cooled neon lamp is taken off at the side and reflected through the disc and thence reflected again, as shown in Fig. 14 (top of bottom disc), through a second, lower, observing hole on the side of the motor cabinet. Because of the small area of the side view of the neon lamp, a lens system is inserted which focusses the image of the lamp at the place to be occupied by the pupil of the operator's eye. When the eye is properly placed, the whole of the lens area is seen filled with light and exhibits the incoming image.

In addition to the monitoring means just described, an additional view of the incoming image is provided by means of a 45° mirror which is carried on the back of a movable shutter which is shown at S in Fig. 4. This shutter carries an illuminated sign on the side turned to the user with the inscription "Watch this space for television image." The shutter with its sign covers the image until the adjustments just described are made, when it is dropped out of sight. While it is in place, the operator is provided with an additional monitoring image reflected from the 45° mirror. This view is, of course, in every respect identical with that which the user sees.

The function of the incoming monitoring system is primarily to enable the operator to set the electrical controls to give the proper quality of image. He also has another task which is that of properly framing the image. This he can do by turning the framing handle, which is described elsewhere, while watching the image from the 45° mirror. This framing operation is preferably performed not on a person sitting in the booth but upon some suitable object such as a mirror located upon the rear door of the booth. In order to make this framing adjustment, the operators at the two terminals set their scanning beam dials to predetermined positions such that the scanning beams place the framing mirrors at the lower edge of the scanning rectangles, the phases of the incoming discs are then shifted until the images of the mirrors are seen properly located in the incoming monitors.

Signalling System

In order to coordinate operations at the two terminal stations, an order wire system is provided. There are four telephone sets at each station; one on the attendant's desk in the ante-room, one concealed inside the television booth, one in the control room, and one at the control panels for the technical operator, who operates the small switchboard which is part of the system. Two of the underground cable circuits connect the two switchboards, so that there may be not more than two separate conversations between stations at one time. Ringing is accomplished by means of standard 20-cycle ringing current furnished by the Telephone Company.

During a demonstration, the attendants' telephones are connected permanently over one of the cable circuits. To relieve the operators of the duty of ringing each time the attendants wish to communicate, a push button and buzzer are provided at each attendant's desk, operated by the standard ringing currents simplexed on the synchronizing circuit. This arrangement leaves the operators free to manipulate the television apparatus.

The two order wire circuits are each simplexed to provide two additional circuits which operate signal lamps indicating to both operators when either chair in the television booths is occupied and turned in position.

Discussion

The primary objects in developing and installing the two-way television system have been two. The first was to obtain information on the value of the addition of sight to sound in person to person communication over the telephone. The second was to learn the nature of the apparatus and operating problems which are involved in a complete television-telephone service. While the installation is entirely experimental, it is being maintained in practically continuous operation for demonstration to employees and guests of the Telephone Company, and interesting data are being gathered on all aspects of the problem.

It may be said without fear of contradiction that the pleasure and satisfaction of a telephone conversation are enhanced by the ability of the participants to see each other. This is, of course, more evident where there is a strong emotional factor, as in the case of close friends or members of the same family, particularly if these have not been seen for some time.

Were the television apparatus and required line facilities of extreme simplicity and cheapness it would be safe to predict a demand for its

early use. At the present time, however, the terminal apparatus is complex and bulky, and requires the services of trained engineers to maintain and operate it. In addition to the cost of the terminal apparatus there is the unescapable item of a many-fold greater transmission channel cost. Because of the wide transmission bands required for the television images, the inherent necessity for a television channel in each direction, and the extra channels for synchronizing and signalling, the total transmission facilities used in this demonstration are those which could, according to current practice, carry about fifteen ordinary telephone conversations. It is to be expected, of course, that development work will result in some increase in the efficiency of the transmitting channels and in simplifications of the terminal apparatus. It is conceivable, therefore, that our present conception of the cost of the whole system may ultimately be materially changed.